Technical Report 430

ACHIEVEMENT IN A SERIAL POSITIONING TASK AND THE ROLE OF LEARNER STRATEGIES

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PERSONNEL AND TRAINING RESEARCH LABORATORY

U. S. Army
Research Institute for the Behavioral and Social Sciences

December 1979

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 19 TR- Technical Report 430	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 ACHIEVEMENT IN A SERIAL POSITIONING TASK AND THE ROLE OF LEARNER STRATEGIES		5. TYPE OF REPORT & PERIOD COVERED 9 Technical rept. May 1979 - June 1979
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 Robert N. Singer, Susan Ridsdale and Gene G. Korienek		8. CONTRACT OR GRANT NUMBER(s) 15 MDA903-77-C-0200
9. PERFORMING ORGANIZATION NAME AND ADDRESS Florida State University Movement Science & Physical Education Dept Tallahassee, Florida 32306		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 16 2Q161102B74F
11. CONTROLLING OFFICE NAME AND ADDRESS Defense Advanced Research Projects Agency 1400 Wilson Boulevard Arlington, Virginia 22209	11	12. REPORT DATE December 1979
		13. NUMBER OF PAGES 65
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) US Army Research Institute 5001 Eisenhower Avenue Alexandria, Virginia 22333	12 77	15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Research accomplished under the technical monitorship of Joseph S. Ward, Army Research Institute

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

serial learning
motor skill
strategies
transfer
retention

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

College students (N = 40) were randomly assigned to one of four conditions in order to ascertain the effectiveness of various learner strategies upon the learning, retention, and transfer of a computer-managed serial motor task. The four conditions were imagery, chunking, rhythm, and control. The subject's task was to move a joystick, which in turn moved a cursor on a monitor, to each of 10 predetermined positions and correct sequence. In general, the typical serial recall curve and the expected primacy-recency effect was not found, perhaps due to the number of responses required on each trial. Imagery

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Unclassified

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and chunking strategies provided more accurate and consistent performance across all 10 positions in the acquisition and transfer tasks. No differences in performance in retention were noted among the groups, although the subjects reproduced positions more accurately after the unfilled retention interval as compared with the filled interval.

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Office, Deputy Chief of Staff for Personnel
Department of the Army

December 1979

Army Project Number
2Q161102B74F

Motor Skill Development and Retention

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FOREWORD

The Personnel and Training Research Laboratory of the Army Research Institute for the Behavioral and Social Sciences (ARI) conducts research to support training methods to optimize skill acquisition and retention. A variety of research is being conducted on the effects of various learning strategies on skill acquisition and retention. ARI, in cooperation with the Defense Advanced Research Projects Agency (DARPA), is especially interested in training strategies for acquisition, retention, and transfer of motor skills. This report is one of several for which research was conducted at Florida State University under contract MDA903-77-C-0020, which was monitored by Joseph S. Ward of ARI under Army Project 2Q161102B74F and funded by DARPA. Mark Anshel and William Redden assisted in data collection for this report.

Joseph Zeidner

JOSEPH ZEIDNER
Technical Director

ACHIEVEMENT IN A SERIAL POSITIONING TASK AND THE ROLE OF LEARNER STRATEGIES

Brief

Requirement:

To analyze and compare the effectiveness of different learner strategies on learning a sequential procedural motor skill task, as part of an investigation on training and retention of motor skills.

Procedure:

A computer-managed task apparatus provided a control stick with which to manipulate a cursor in a predetermined position sequence. Four learning strategies were randomly assigned among 40 college-age participants: (1) imagery, with instructions to use mental pictures to remember the response sequence; (2) chunking, with instructions to remember responses in groups of three; (3) rhythm, with instructions to use a self-generated rhythmic count to help remember the motion sequence; and (4) control, with no strategy instructions.

Each participant received instructions and a demonstration-practice session, then eight acquisition trials; after a short rest, a one-trial retention test, a short break, and an eight-trial transfer task with different position sequences.

Findings:

Mean performance in the transfer task was significantly more accurate than in the acquisition trials. The increased accuracy may reflect familiarization with both the strategy usage and the task. In general, errors increased from first to last of the 10 positions; the imagery and chunking strategies produced fewer errors overall.

Utilization of findings:

Basic research on how people learn to perform complex sequential motor actions contributes to the development of more effective training of many military skills.

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INTRODUCTION

In previous studies (Hagenbeck, Singer, & Gerson, Note 1; Singer, Gerson, & Ridsdale, Note 5), we have used a serial positioning task in order to determine the effectiveness of different learner strategies as aids to the learning process. The present investigation represents an extension of this work.

It has been hypothesized that the learning of an appropriate strategy will enhance the skill acquisition process. Furthermore, retention and transfer should be improved if the strategy is effective and indeed, if it is applied correctly by learners. A serial positioning task can provide interesting data with regard to performance in two ways. First, there are data across positions for each trial, thereby providing a standard trial by trial analysis. Second, positional data can be analyzed across trials, indicating the nature of the serial position learning curve as a function of experimental conditions.

The typical serial positioning curve reflects a primacy-recency effect whereby the best performance is shown with last and first learned items, assuming that the number of the items (or positions) is not too small or too large. Perhaps this is why Magill (1976) obtained a linear acquisition curve with three positions and others (Gerson & Thomas, 1978; Magill & Husak, Note 3; Wilberg & Girard, 1977; Wrisberg, 1975) have reported serial position curves when the sequence length approached or barely exceeded the subject's theoretical processing capacity. It would appear that Miller's (1956) classic study on capacity might hold true here, if each position on a trial might be considered as a bit of information, and 7 bits $\pm$ 2 are the average number of bits that are processed on each occasion.

The serial positioning curve was evidenced as well by Hagenbeck, Singer, & Gerson (Note 1) when subjects had to learn six criterion positions in sequential order. However, certain learner strategies elevated the response scores in the middle position targets. The groups that were taught imagery and relevant labeling out-performed the irrelevant labeling, kinesthetic awareness, and control groups in these positions in general. Apparently relevant labeling, and especially imagery, facilitates the nature of input and response organization and retrieval. Interference effects were apparently less pronounced. In addition, the poorer accuracy (AE) and greater variability (VE) across trials of the irrelevant labeling, kinesthetic, and control groups as compared to the other two groups appear to indicate that appropriate strategies can aid the skill acquisition process.

In the subsequent study (Singer, Gerson, & Ridsdale, Note 5), the trend for the serial positioning curve was observed for the kinesthetic group but not so apparent for the labeling, informed choice, and control groups with AE as the dependent measure. The imagery group did not reveal any sign of this curve and was generally most accurate at each position. Somewhat similar patterns unfolded with VE, with imagery generally most effective across all positions, but especially in the middle ones. Surprisingly, the control group was about as effective on positions 4 and 5. When acquisition and transfer were considered across all trials and positions, imagers performed best, followed by the control group subjects. The performance of the control group was surprising and difficult to explain, although some procedural differences existed between this study and the one described previously.

In the present study, the number of positions was increased to 10 in order to determine if the serial positioning curve would still exist, and, if so, whether learned strategies would make any difference in performance. Furthermore, the experiment was computer-managed, the first such serial positioning task reported in the literature. Considerations, especially with regard to strategy directions, were somewhat unique. But the experimental paradigm, consistent with the Singer, Gerson, & Ridsdale (Note 5) study reported earlier; and an investigation involving the learning of a procedural task (Singer, Ridsdale, & Korienek, Note 7) and a tracking task (Singer, Ridsdale, & Korienek, Note 6) was followed in the present study. In all of these experiments, the attempt is to determine the effectiveness of learner strategies on the acquisition, retention, and transfer of tasks.

An effective learning strategy has been defined as the simplest and most efficient means of processing the information inherent in a situation (Newell & Simon, 1972). Rigney (1978) suggested that a strategy may be interpreted as signifying operations and procedures a learner may adopt to acquire, retain, and to retrieve different kinds of information. Similarly, Bruner, Goodnow, and Austin (1956) have written that a strategy provides the learner with a pattern of decisions for the acquisition, retention and future utilization of information. We (Singer & Gerson, in press) have defined a strategy as a self-initiated or externally imposed means of utilizing information that leads to decisions for purposeful behavior. Based upon an interpretation of the preceding definitions, it would appear that a strategy, or combinational strategies, developed by the learner in accordance with his/her cognitive abilities and situational demands, are effective in relating new information to previously obtained knowledge (Bruner, 1961).

Within the area of verbal learning, the use of learner strategies has facilitated the acquisition and retention of specific information across a variety of age groups (Belmont & Butterfield, 1971; Bruner, Goodnow, & Austin, 1956; Hagen, Hargrove, & Ross, 1973; Kingsley & Hagen, 1975). Various strategies such as mnemonics, encoding, rehearsal, and labeling have proven to be effective in the acquisition and retention of information for immediate recall. Typically, experiments involve the presentation of letter lists which must be committed to memory in order to be recalled immediately following presentation. The effectiveness of particular strategies is usually assessed by the length of interim pauses during list learning (Belmont & Butterfield, 1971) and correctness of response during serial recall (Maccoby & Hagen, 1965).

The implication for motor learning would appear to be that the use of strategies should facilitate the learning process. However, while there exists an abundance of supportive evidence for strategy usage within the verbal learning area, research is severely lacking within the motor learning domain. Thus, inferences must be drawn from verbal learning research as to the potential beneficial effects of various types of strategies on the acquisition and retention of motor skills.

In an attempt to apply verbal labeling strategies to a motor task, Shea (1977) required subjects to reproduce a single criterion position on a manual lever positioning apparatus after experiencing the movement once. Of the three groups tested, one group was provided with relevant labels, one group created its own irrelevant labels, and one group had no labels. The relevant labeling group showed significantly higher recall scores than either of the other two groups. Additionally, no decrement in recall was observed over time (60 sec) when relevant labels were provided. Such results lend credence to the notion that a meaningful labeling strategy enhances the storage of information as well as facilitating later recall.

Similarly, Housner and Hoffman (Note 2) investigated the role of imagery in the reproduction of criterion points and locations. Subjects were instructed to formulate a mental picture of their hands moving to the criterion position or at the end location point. During rest intervals, some subjects were required to employ imaginal rehearsal while others were prohibited from rehearsing by the use of distractor tasks. Results indicated that those subjects who applied the imagery strategy during the movement to end locations and also during rest intervals displayed superior recall of the criterion points.

The lack of research concerning strategy effectiveness within the motor learning area has necessitated a heavy reliance upon the findings reported in the verbal learning literature. In many of these investigations, serial recall tasks have been used, where subjects are given words successively and are then required to report them in the same order presented. Such tasks are representative of the serial events in everyday life that require an individual to learn what item follows or is adjacent to another in a spatial or temporal array.

However, while the serial recall tasks developed by verbal learning theorists require individuals to recall and then verbally repeat, serial motor tasks would appear to involve both cognitive and motoric response processes. For example, consider the novice learning to execute a routine on the uneven parallel bars or an individual attempting to recall and reproduce a card-sorting sequence. The task demands in these two situations require the mastery of a sequential set of events. A serial set of responses needs to be performed correctly, temporally and spatially, in order for the entire activity to be judged as acceptable.

Both imagery and labeling strategies have been shown to enhance the learning of a repositioning task (Hagenbeck, Singer, & Gerson, Note 1; Housner & Hoffman, Note 2). However, since the task additionally requires movement to a specific location, kinesthetic information concerning the feel of that movement may be of value to the learner (Schmidt, 1975).

Therefore, it was the purpose in the present study to analyze the effectiveness of various strategies on acquisition, retention, and subsequent transfer with a repositioning task. The following strategy conditions were investigated: imagery, labeling, and chunking.

In line with the consistent finding that strategy usage enhances initial learning, it was hypothesized that subjects applying a particular strategy would display superior performance across all three conditions (acquisition, retention, and transfer) when compared to control subjects who used no designated strategy. Previous research (Hagenbeck, Singer, & Gerson, Note 1; Housner & Hoffman, Note 2; Singer, Gerson, & Ridsdale, Note 5) with repositioning tasks has indicated superior learning for imagery strategy groups. Therefore, it was hypothesized that during acquisition and retention trials, subjects in the imagery group would perform better than either the chunking or labeling groups. However, these two groups were hypothesized to perform better than the control group.

Although the potential for the transfer of strategies from one task to another is evident, relatively few investigators have dealt specifically with this area. Imposed strategies may enhance initial learning and retention; however, transfer requires an individual to identify the existent similarities between tasks' similar processing demands. It was hypothesized that subjects in the strategy choice groups would display a greater degree of transfer learning between the acquisition and transfer task.

METHODS

Subjects

Forty male and female undergraduate and graduate students (M age = 24.50 yrs; SD = 5.30) from Florida State University volunteered to participate in this study.

Apparatus

The Serial Position Apparatus (SPA) is a computer managed task that requires the interaction of two computer systems for its operation. A Control Data Cyber 74 stored the system program that was used to generate the control programs for the SPA, and an Imsai 8080 microcomputer actually controlled the program operation and handled the input/output responsibilities. Data recorded by the microcomputer were transmitted to the Cyber 74 for storage and future analysis. The two systems were linked via an Astroset modem using a Lear-Siegler ADM-3A Interactive terminal as the communication interface.

A Sony CUM-51WWD video monitor allowed the experimenter to monitor the progress of the subject, while a Sony CUM-2204A 23 in. video monitor displayed the task instructions, cursor positionings, and knowledge of results to the subject. Audio communications between the subject and experimenter were maintained with a Bogen CHB-35A communication system. The subject interface with the SPA was a Cromemco JS-I joystick module consisting of a 20 cm x 15 cm x 9 cm metal box with a 5 cm long metal rod, 5 mm in diameter, protruding from the center of the horizontal surface. Next to the rod, on the same surface, were four buttons numbered one through four.

The SPA program displayed a cursor (a white rectangle 5 mm x 10 mm) on a 23 in. video screen, and prompted the subject to move the cursor to specific positions along a horizontal line in the middle of the screen. By moving the joystick to the right or left, the subject could position the cursor to any of the 64 stop positions along the line. The relationship of joystick deflection to cursor movement was held constant by programming the cursor to move with a velocity of 15 cm/sec for the acquisition and retention phases of the experiment and 20 cm/sec for the transfer phase of the experiment. The movement of the cursor began with the deflection of the joystick and stopped when the joystick was returned to the center position.

The subject's task was to move the joystick, which in turn moved the cursor to each of 10 demonstrated stop positions, and indicate each of the positions in sequence by pressing the number 4 button on the joystick module. Each sequence began with the cursor located in the center of the screen. The subject moved the joystick, which moved the cursor, to the demonstrated first stop position. Then he or she pressed the button, and the cursor returned to the center of the screen. The subject then moved it to position 2 and pressed the button, and repeated this action until 10 positions had been completed. A diagram of the control system of the apparatus is presented in Figure 1 and an illustration of the equipment layout for the subject and experimenter is presented in Figure 2.

Procedure

Subjects entered the test area and a strategy condition was randomly assigned to each subject. The subject was then seated in a chair facing the apparatus, which was

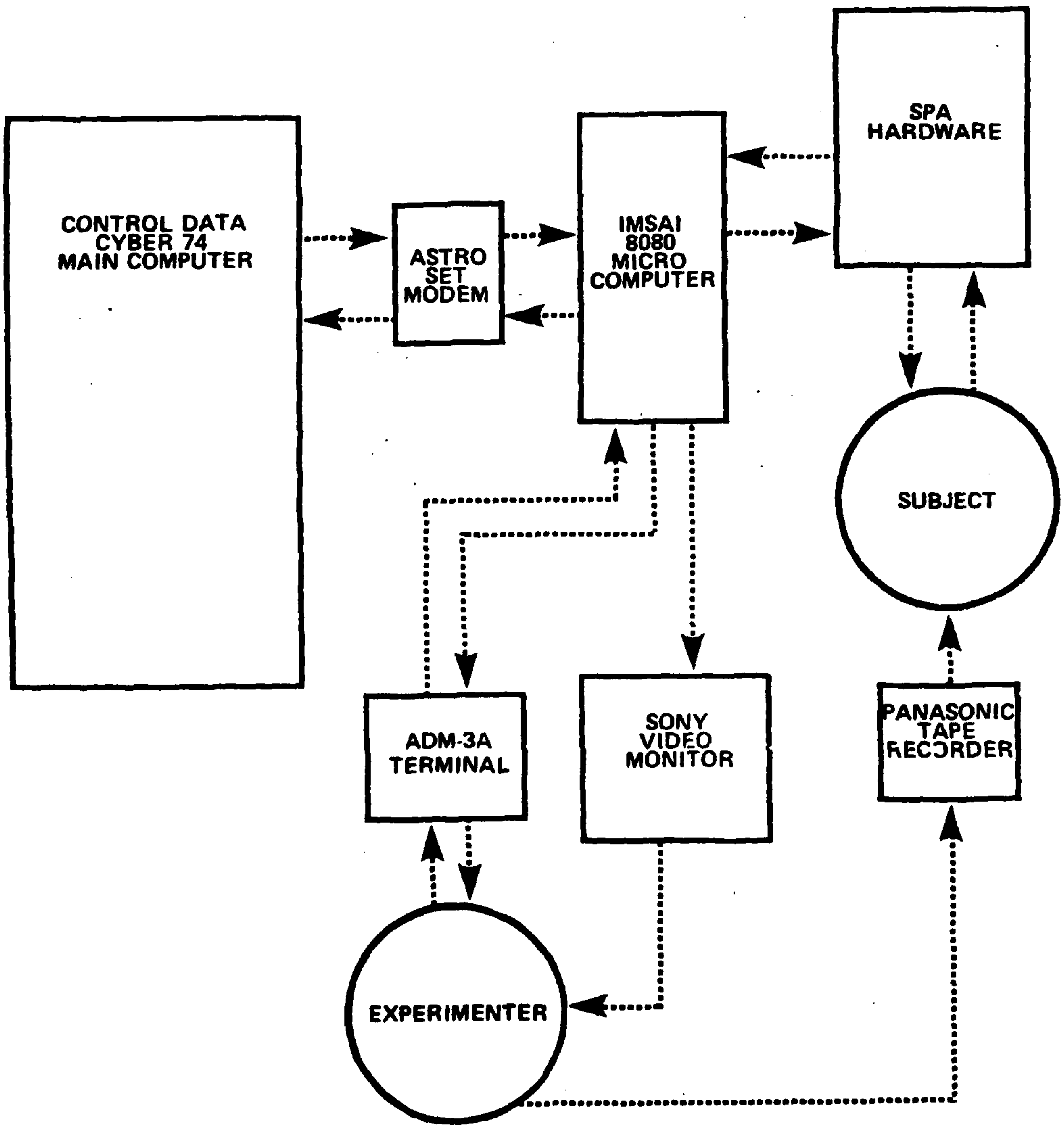

Figure 1. Control system for the Serial Manipulation Apparatus.

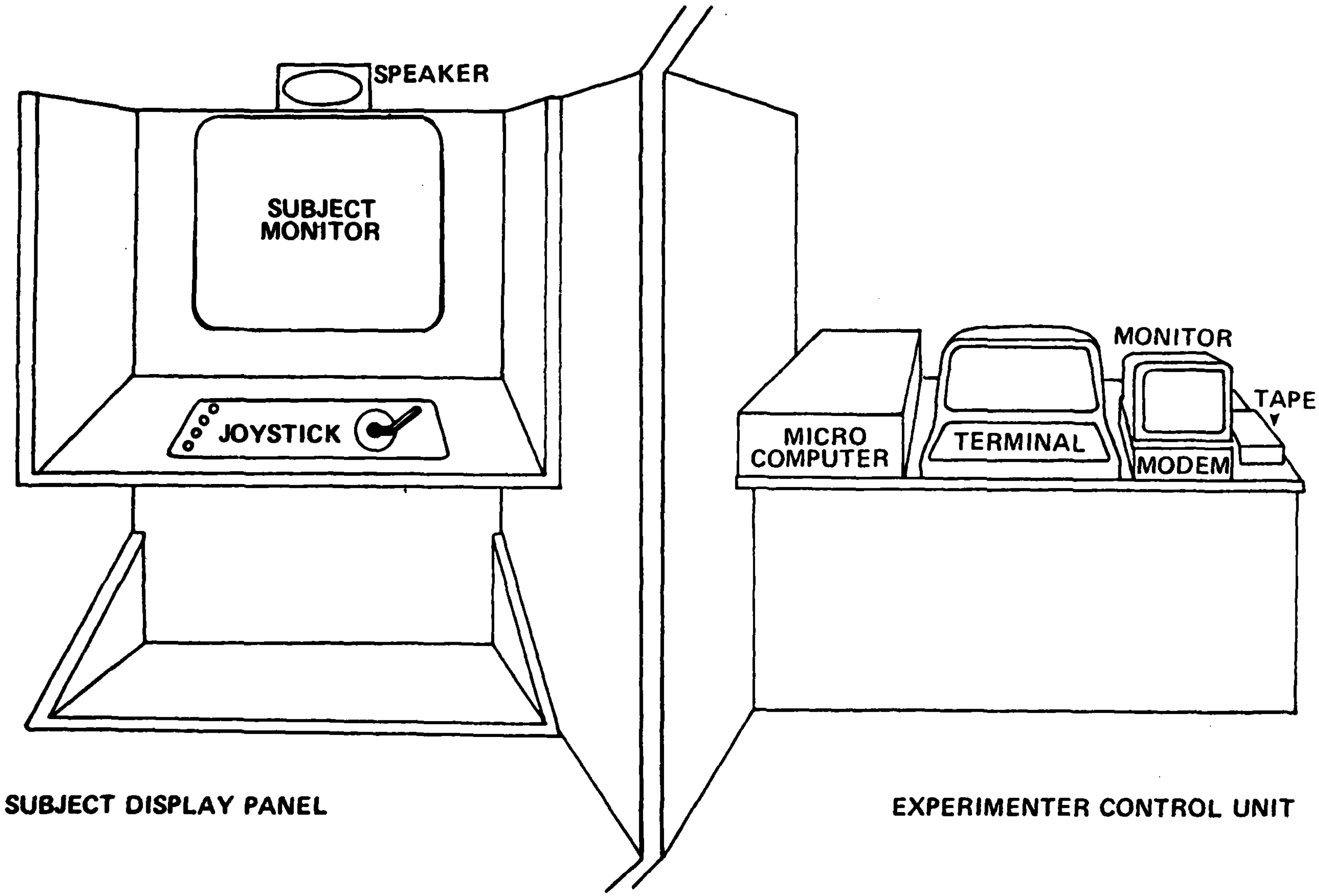

Figure 2. Equipment layout for the subject and experimenter.

situated on a table 80 cm in height. Each subject was aligned with the apparatus in a way such that the joystick was in line with the midline of the subject's body. Subjects were then instructed in the operation of the apparatus and trained in the application of the particular strategy assigned to them as they entered the test area. There were four strategy conditions: (a) imagery, (b) chunking, (c) rhythm, and (d) control, where subjects received no instructions as to strategy usage but were not restrained from self-generating a strategy. Instructions for each condition are located in the Appendix. Following training unique to each group, all subjects were given one demonstration of 10 stop positions. All stop positions were randomly selected prior to the experiment with the restriction that no two successive stop positions would occur within 3 cm of each other. The subject's task during the demonstration-practice portion of the study was to move the cursor to the right or left from its starting point in the center of the video monitor. The decision of the subject to move right or left was made in response to a prompt displayed on the monitor indicating the direction to move in order to locate the next stop position in the sequence. When the subject positioned the cursor over the appropriate position, the computer would indicate that the correct position had been located, print the number of that position in the series of 10 positions, and then display the directional prompt indicating in which direction the subject should move the cursor to find the next stop position in the sequence. This series of events was repeated for each stop position until the locations of all 10 positions had been demonstrated. When the demonstration was completed, the monitor displayed all 10 positions numbered in the sequence of presentation. The duration of this presentation was 15 sec.

Immediately following the demonstration-practice, subjects in each group attempted to replicate the 10 stop positions during 8 acquisition trials. Knowledge of results (KR) in the form of constant error at each position and total absolute error were displayed on the monitor for 20 sec after every trial. In order to ensure that each subject had sufficient time to apply the KR information, and to think about a strategy or approach to mastering the task, a 10 sec inter-trial post-KR period was administered. On all evenly numbered trials (with the exception of trial 8) subjects were cued (reminded) to continue to use their specific strategy. Upon completion of the eighth acquisition trial, all groups were randomly subdivided for the retention phase of the study.

Subgroup 1 subjects received a one trial recall test for all 10 stop positions after a 20 sec unfilled retention interval. During this interval, the subject rested while waiting to replicate the criterion positions. Subgroup 2 subjects were required to verbally count backward from 100 by decrements of 3 during a 20 sec filled retention interval prior to the recall test. Following the retention test there was a 2 min rest period before the beginning of the transfer task. During the rest period, a questionnaire concerning the use of strategies was administered to each subject (see Appendix).

For the transfer task, 10 different stop positions were randomly generated under the same previous restrictions. All procedures for this phase of the study were identical to those used in the acquisition phase with the exception that no mention was made of strategy usage. No strategy cues were given. Additionally, subjects were not required to perform a retention test, although they did respond to the same questionnaire that was administered following the retention test, with all questions asked relative to the transfer phase of the task. Figure 3 contains a schematic design of the sequential procedures followed throughout the entire experiment.

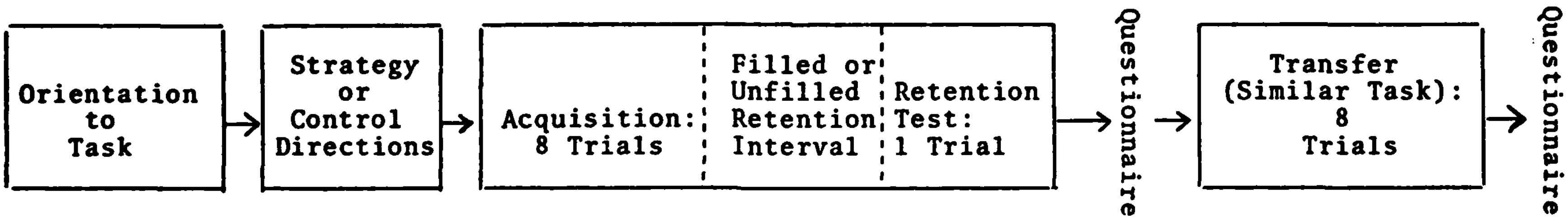

Figure 3. Sequential procedures in the experiment.

RESULTS

The existent controversy within the movement reproduction paradigm regarding the selection and interpretation of an individual's error measures has generated numerous opinions as to the appropriateness of absolute, constant, variable, and other error scores (Safrit, Spray, & Diewert, in press; Schutz, Note 4). However, it has been suggested recently that measures of error should reflect behavioral constructs, and thus be chosen upon behavioral rather than statistical bases (Newell, 1976; Safrit et al., in press). Since the purpose of the present study was to investigate the effectiveness of various learner strategies upon motor learning, it was thought that AE would be the most pertinent measure of performance differences among strategy groups. Therefore, although AE, CE, and VE error scores are reported, the emphasis in the Results and Discussion sections of this paper is on the AE score.

Absolute Error

A 4 x 2 x 10 x 8 (strategies X tests x positions x trials) factorial ANOVA, with repeated measures on the last three factors, yielded two significant main effects, two 2-way interactions, and one 3-way interaction.

The test main effect was significant F (1, 36) = 10.558, $p < .01$ indicating that subjects were more accurate during the transfer phase of the experiment than in the acquisition phase.

The positions main effect was also significant, F (9, 324) = 6.271, $p < .01$. Although post hoc Newman-Keuls analysis failed to discern the locus of positional differences, a general poorer performance from first to last position can be observed in Figure 4, rather than the typical inverted U-shaped curve associated with the primacy-recency effect. Mean scores for each of these main effects and all subsequent significant effects are provided in Table 1.

The strategies x positions interaction was significant, F (27, 324) = 1.57, $p < .05$ and follow-up comparisons indicated that the control group was less accurate at position 8 than all three strategy groups, which were not different from each other. Additionally at position 10, the rhythm group was less accurate than either of the other three groups, which in turn were not different from each other. The strategies x positions interaction is illustrated in Figure 5.

The significant tests x positions interaction, F (9, 324) = 4.13, $p < .01$, indicated that during the transfer phase, subjects were more accurate in locating positions 3, 4, 9, and 10. This interaction is shown in Figure 6.

Finally, the strategies x tests x positions interaction

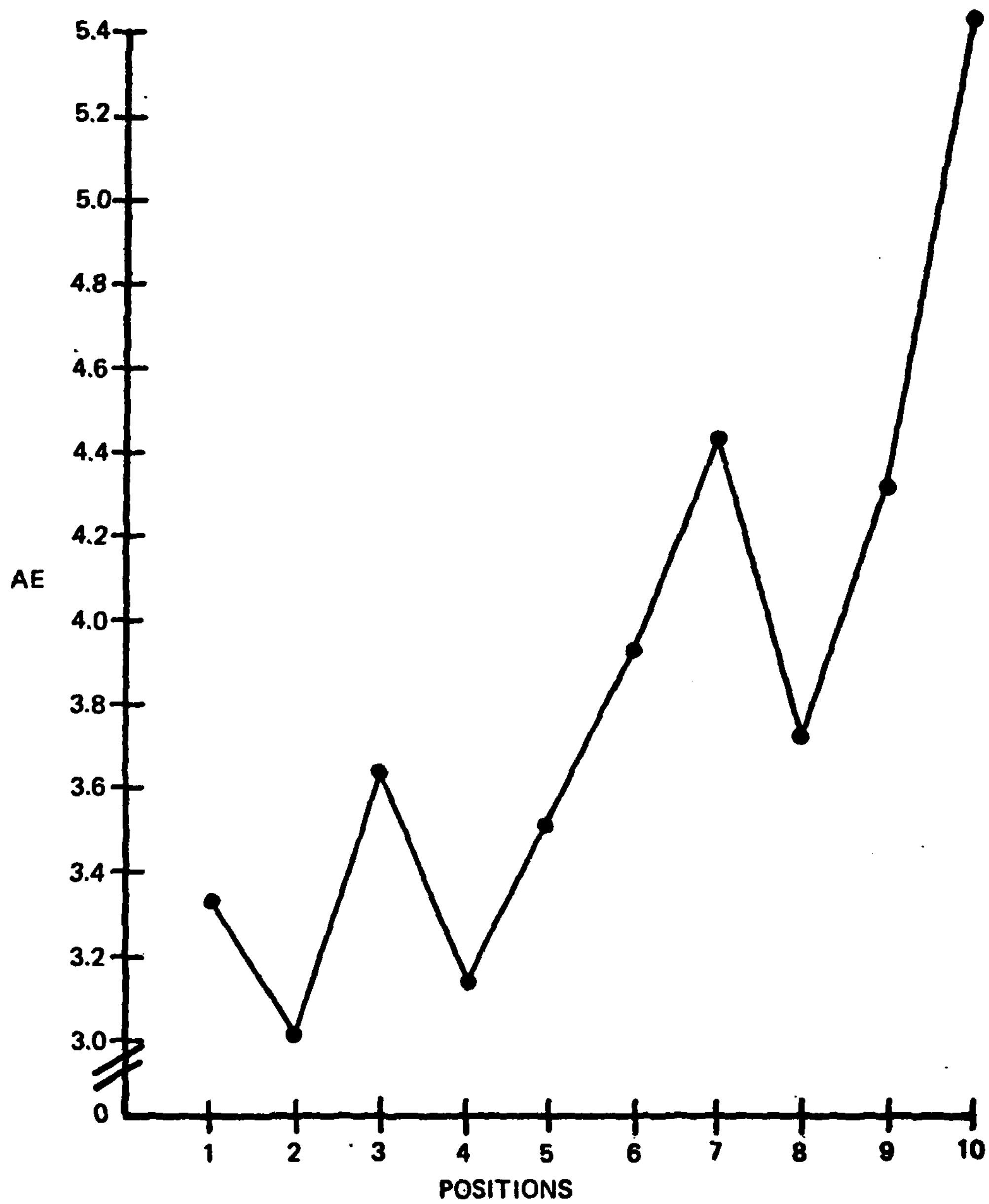

Figure 4. Positions main effect for AE.

Table 1

Mean Scores for Significant Effects for AE (in degrees)

Test			Acquisition				Transfer			
			4.491				3.218			
Position	1	2	3	4	5	6	7	8	9	10
	3.305	3.036	3.664	3.122	3.533	3.938	4.405	3.727	4.391	5.745
Strategy / Position	1	2	3	4	5	6	7	8	9	10
Imagery	3.525	2.994	2.863	2.594	3.481	3.600	4.019	1.906	3.725	4.381
Chunking	2.294	2.413	3.181	2.638	3.338	3.713	3.250	2.794	3.513	4.444
Rhythm	3.756	3.313	4.838	3.506	3.094	4.681	4.725	3.931	5.038	7.594
Control	3.644	3.425	3.775	3.750	4.219	3.756	5.625	6.275	5.288	5.281
Test / Position	1	2	3	4	5	6	7	8	9	10
Acquis.	3.453	3.434	4.647	4.397	3.583	3.909	4.956	4.056	5.784	6.691
Transfer	3.156	2.638	2.681	1.847	3.481	3.966	3.853	3.397	2.997	4.160

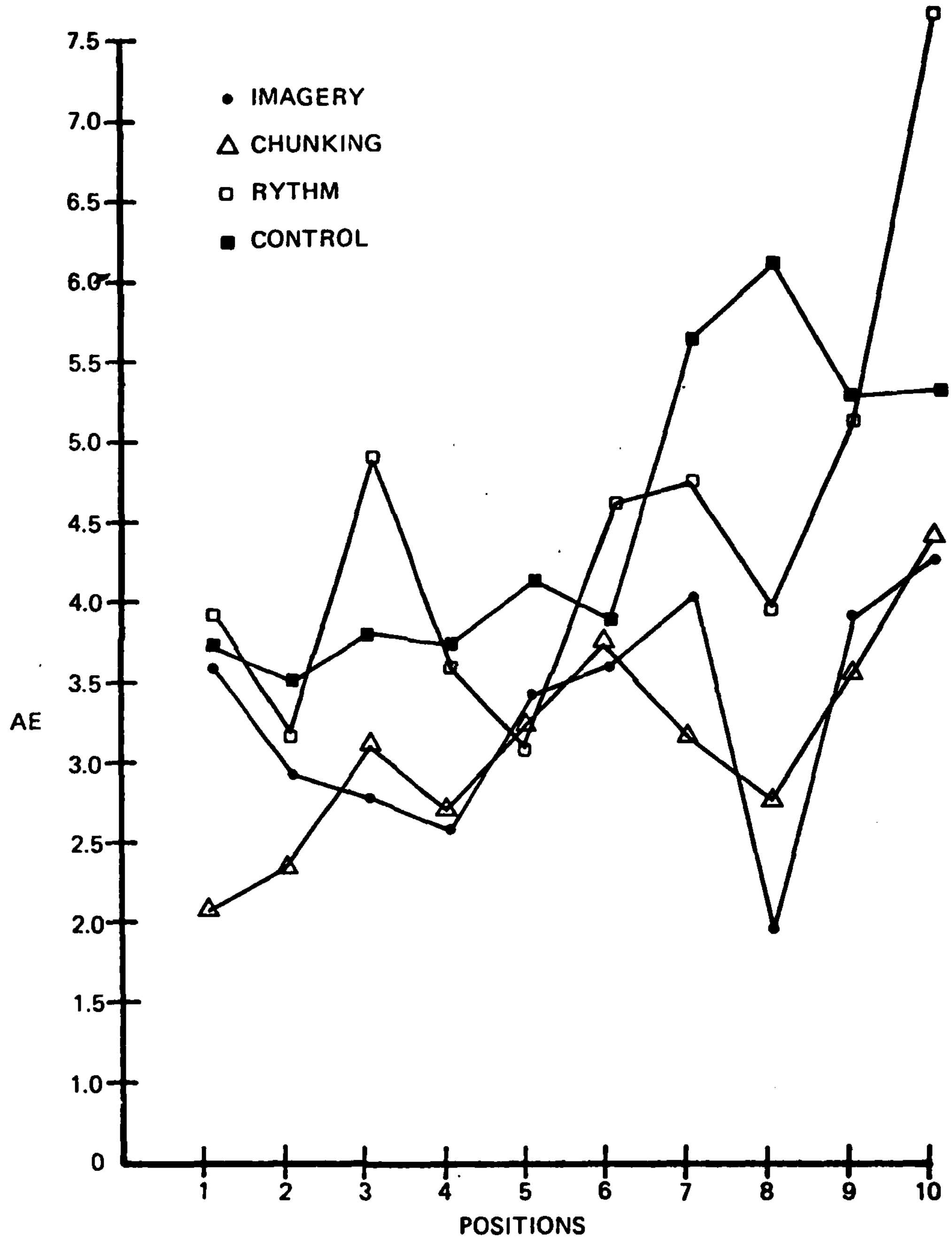

Figure 5. Strategies x positions interaction for AE.

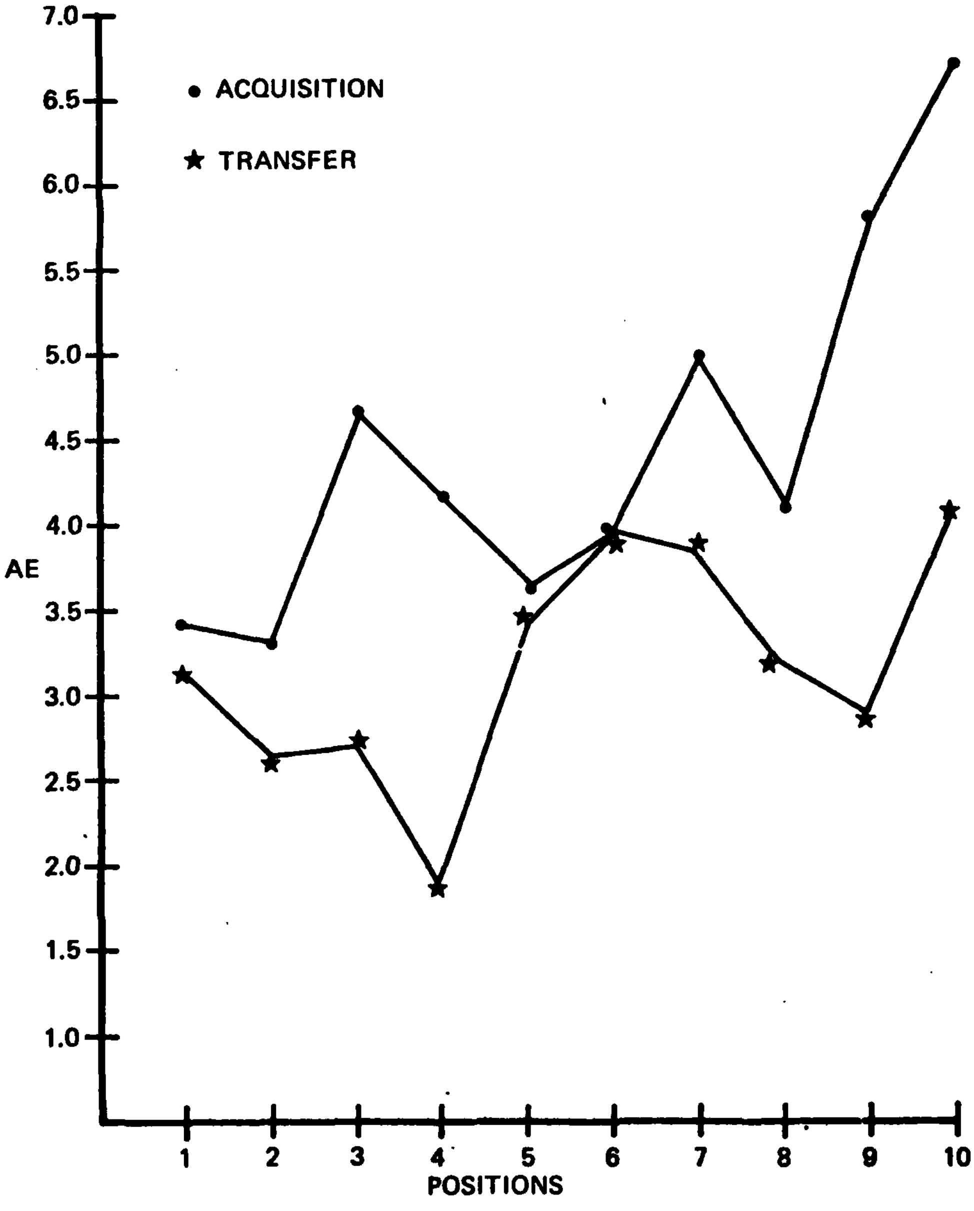

Figure 6. Tests x positions interaction for AE.

was found to be significant, F (27, 324) = 1.75, $p < .01$. Table 2 contains the mean error scores for groups by position during acquisition and retention conditions. Follow-up Newman-Keuls comparisons yielded the following differences during acquisition.

The rhythm group was less accurate than either the chunking, imagery, or control groups at position 3. The chunking group was more accurate than the imagery, rhythm or control groups at position 7. At position 8, the control group was less accurate than the three strategy groups. The rhythm group was less accurate than either the chunking or imagery groups, which were not significantly different from each other.

The chunking group was significantly more accurate than the other three groups at position 9. Finally, at position 10, the imagery group was more accurate than the rhythmic group. Additionallly, during the transfer phase, the rhythm group was less accurate than the other three groups, and the imagery group was significantly more accurate than the control group.

A secondary analysis was conducted on the AE scores to determine if effects of the interfering activity existed during the retention interval and if performance on the one-trial retention test differed from performance on the last trial of the acquisition test. Although the

Table 2

Mean Scores for Group X Test X Position Interaction for AE (in degrees)

Position	1	2	3	4	5	6	7	8	9	10
Strategy: Imagery										
Acquis.	3.424	2.800	3.225	4.300	4.763	3.725	4.875	1.288	5.563	6.775
Transfer	3.625	3.188	2.500	.888	2.200	3.475	3.163	2.525	1.888	1.988
Chunking										
Acquis.	2.463	3.163	3.213	3.450	2.513	3.700	2.938	2.338	3.675	4.738
Transfer	2.125	1.663	3.150	1.825	4.163	3.725	3.563	3.250	3.350	4.150
Rhythm										
Acquis.	3.950	4.213	7.175	5.575	2.563	4.588	5.475	4.488	6.288	8.650
Transfer	3.563	2.413	2.500	1.438	3.625	4.775	3.975	3.375	3.788	6.538
Control										
Acquis.	3.975	3.563	4.975	4.263	4.500	3.625	6.538	8.113	7.613	6.600
Transfer	3.313	3.288	2.575	3.238	3.938	3.888	4.713	4.438	2.963	3.963

filled/unfilled effect was not significant, there was a main effect for positions, $F\ (9, 288) = 2.04$, $p < .05$. The follow-up test indicated that subjects were significantly less accurate on position 10 than on positions 1, 2, 3, 5, 6, or 8, which were not significantly different from each other.

Additionally, the strategies x positions interaction was significant, $F\ (27, 288) = 1.83$, $p < .01$. Newman-Keuls follow-up comparisons indicated the following differences. At position 2, the control group was more accurate than either the imagery or control group. The chunking group was more accurate than all three other groups at position 3. At positions 4, 5, and 6, the imagery group was less accurate than the three other groups. The imagery group was less accurate than all remaining groups at position 7, with the rhythm group performing more accurately than the imagery group. At position 8, both the chunking and imagery groups were more accurate than the control. For position 9, the imagery group again showed significantly less accuracy than all other groups. Additionally, both the chunking and control groups were more accurate than the rhythm group. Finally, at position 10, the imagery group was less accurate than the other three groups, with both chunking and control groups performing more accurately than the rhythm group. The mean scores for both significant effects are shown in Table 3. The strategies x positions interaction is illustrated in Figure 7.

Constant Error

A 4 x 2 x 10 x 8 (strategies x tests x positions x trials) factorial ANOVA, with repeated measures on the last three factors, yielded a significant positions effect, F (9, 324) = 11.07, $p < .01$, and a significant tests x positions interaction, F (9, 324) = 4.61, $p < .01$. As in the typical range effect, long movements were undershot. This phenomenon is illustrated in Figure 8 by the response biases at positions 4 and 10 for acquisition and 1 and 10 for transfer. However, unlike the typical range effect, short movements displayed little, if any, response bias. The mean scores for both significant effects are shown in Table 4 and Figure 9.

A secondary analysis was conducted on the CE scores to determine any effects of the interpolated activity during the retention interval, and if performance on the one-trial retention test differed from the last acquisition trial. The factorial ANOVA yielded three main effects, a two-way interaction and a three-way interaction. The means for all significant effects appear in Table 5.

The strategies main effect was significant, F (3, 32) = 3.00, $p < .05$, but post hoc Newman-Keuls analysis failed

Table 3

Mean Scores for Significant Effects for AE During Retention Interval

Position	1	2	3	4	5	6	7	8	9	10
	3.288	3.525	3.863	4.475	3.625	3.650	4.513	3.563	4.463	5.775
Position / Group	1	2	3	4	5	6	7	8	9	10
Imagery	3.900	4.150	4.950	7.550	7.200	7.400	6.950	2.250	7.750	10.050
Chunking	2.500	3.100	1.850	3.450	2.450	2.450	2.800	1.700	2.200	3.450
Rhythm	3.100	4.550	4.550	4.650	1.800	2.800	4.050	5.100	4.650	5.600
Control	3.650	2.300	4.100	2.250	3.050	1.950	4.250	5.200	3.250	4.000

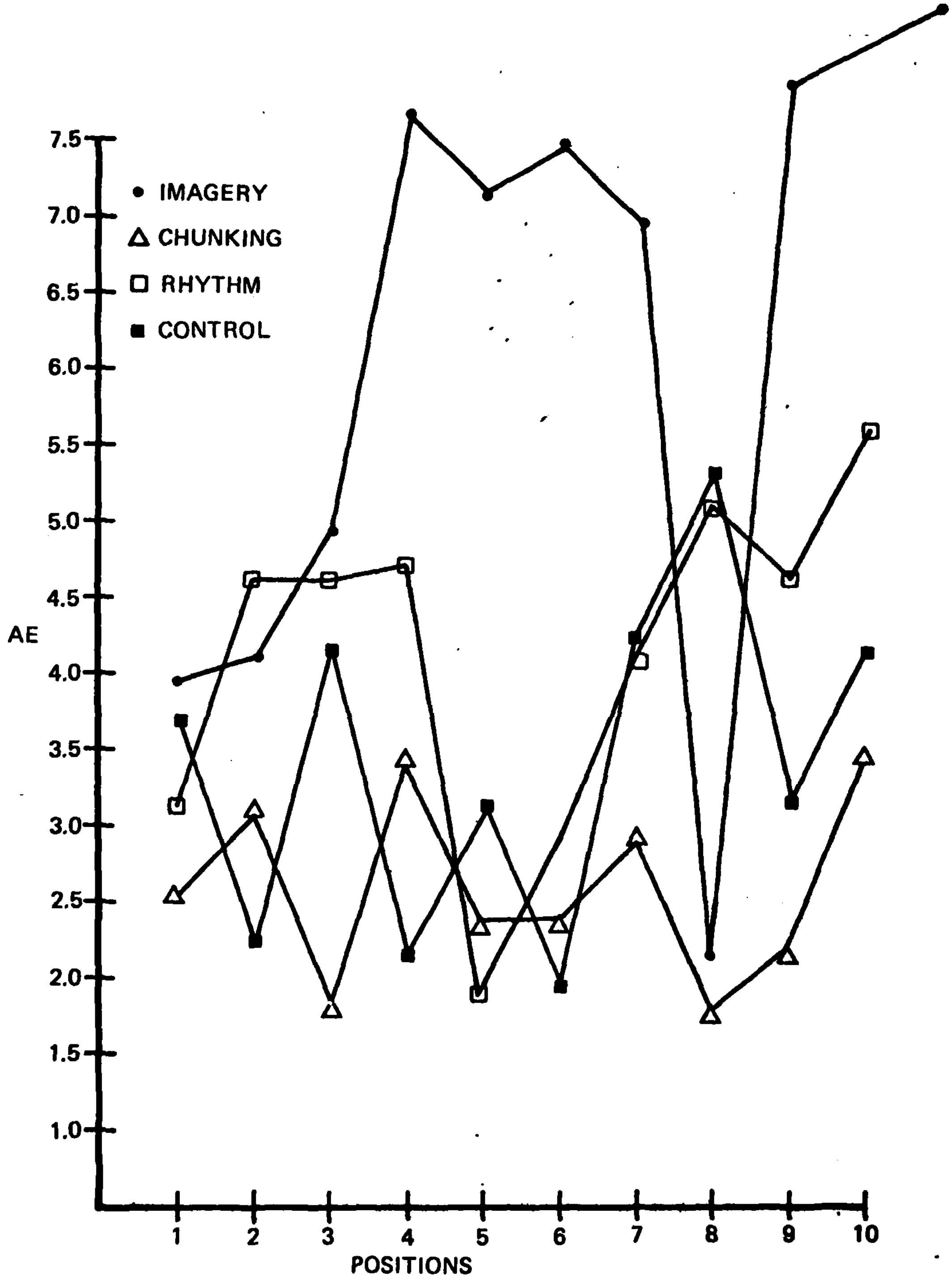

Figure 7. Strategies x positions interaction for AE during retention interval.

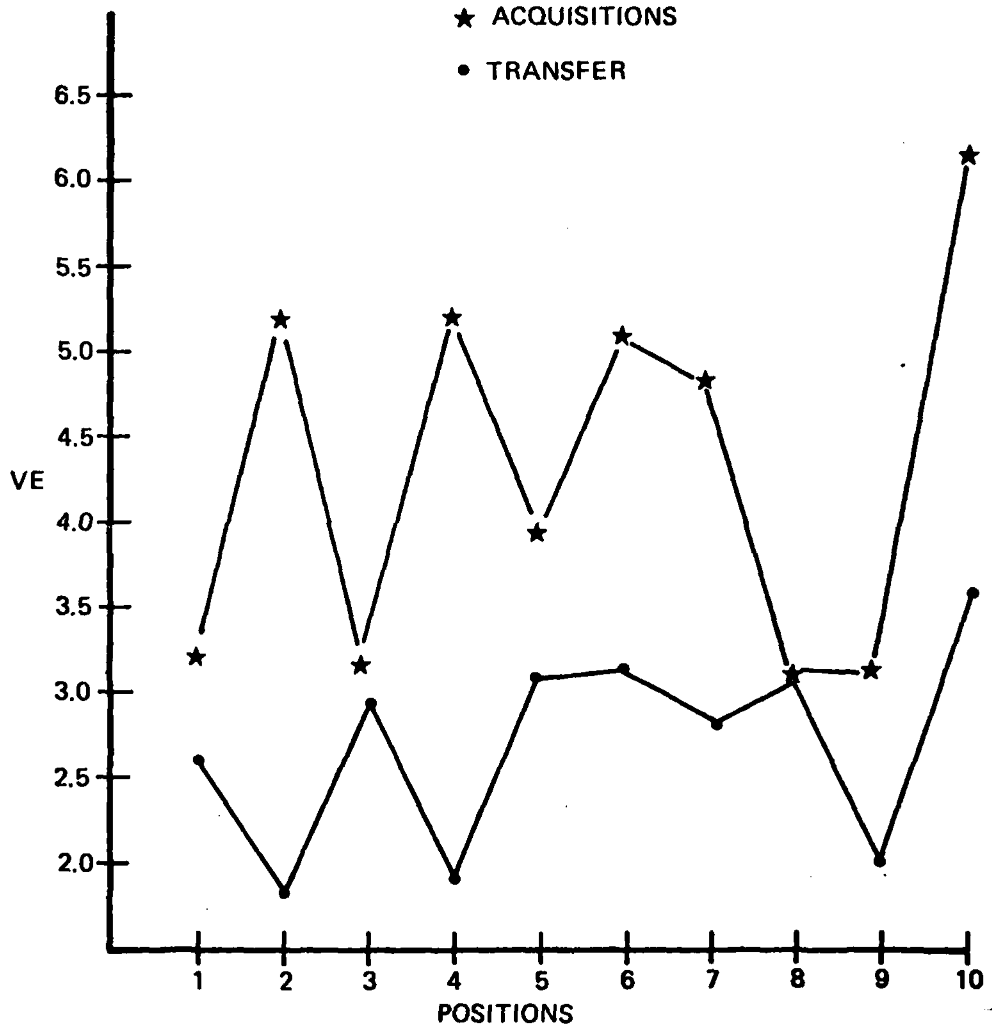

Figure 8. Positions x tests interaction for VE.

Table 4

Mean Scores for Significant Effects for CE

Position	1	2	3	4	5	6	7	8	9	10
	-.799	.039	1.264	-1.928	-1.352	-.013	-.923	.727	.816	-3.638
Position / Test	1	2	3	4	5	6	7	8	9	10
Acquisition	.272	-.453	1.228	-2.809	-.234	-1.453	-.506	1.600	.341	-5.253
Transfer	-1.869	.531	1.300	-1.047	-2.469	1.428	-1.341	-.147	1.291	-2.022

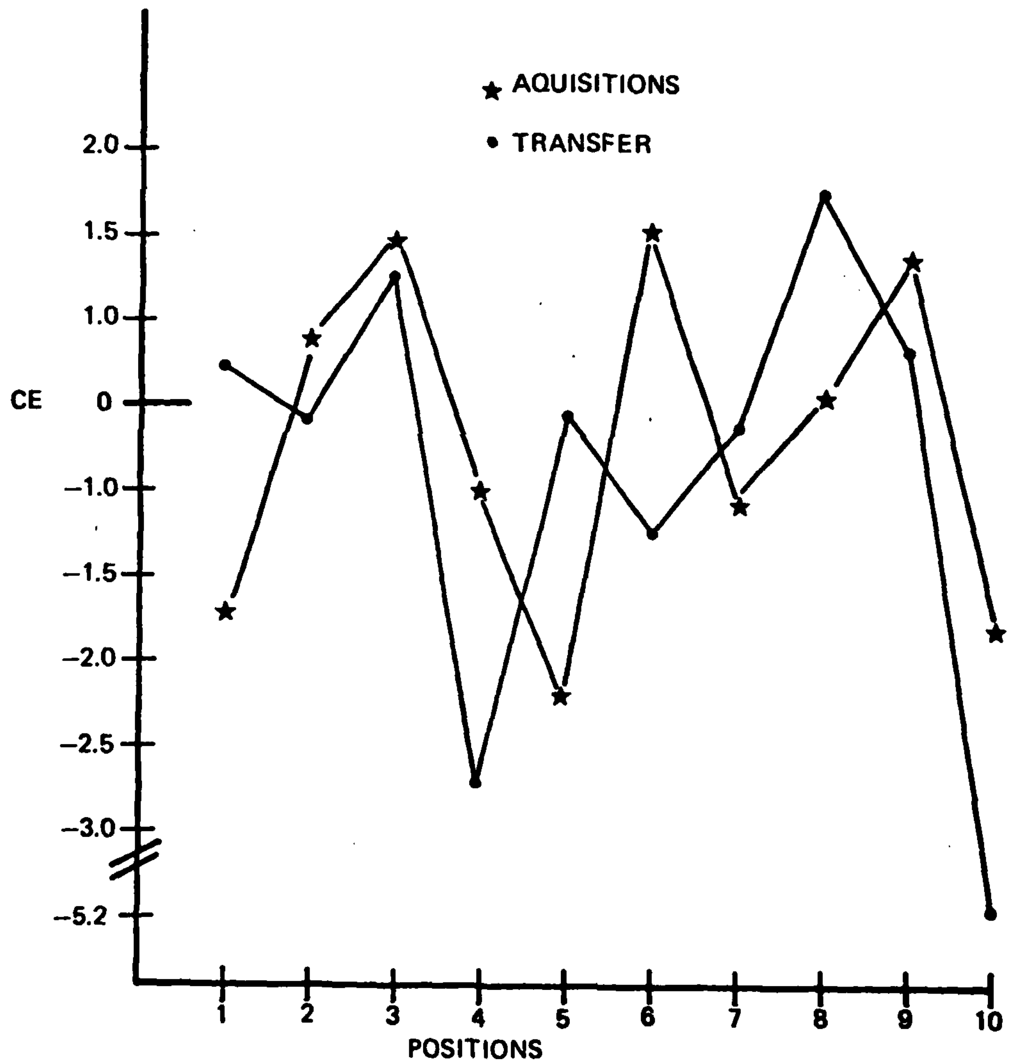

Figure 9. Tests x positions interaction for CE.

Table 5

Mean Scores for Significant Effects for CE During Retention Interval

Group	Imagery			Chunking			Rhythm		Control	
	-1.5750			-1.085			-.175		-1.020	
Interval	Filled			Unfilled						
	-1.420			-.508						
Position	1	2	3	4	5	6	7	8	9	10
	-.413	-.625	.938	-2.850	-.575	-2.450	-1.013	1.938	-.463	-4.125
Position / Strategy	1	2	3	4	5	6	7	8	9	10
Imagery	1.700	-2.950	2.750	-6.750	-.900	-6.300	2.450	-.750	3.650	-8.650
Chunking	-1.600	-1.000	-1.750	-.950	.450	-1.450	-.400	1.100	-2.000	-3.250
Rhythm	-1.100	3.050	2.650	-2.650	.300	-1.200	-2.850	4.500	-1.650	-3.300
Control	-.650	-1.600	.100	-1.550	-2.150	-.850	-3.250	2.900	-1.850	-1.300

to discern the locus of mean differences. However, as can be seen in Table 5, the rhythm group displayed less response bias than the imagery group.

The type of interval was significant (filled/unfilled) F (1, 32) = 7.39, $p < .05$, indicating that subjects reproduced positions more accurately after the unfilled interval.

The positions main effect was also significant, F (9, 288) = 4.11, $p < .01$. Post hoc comparisons revealed that greater response errors occurred at position 10 than at positions 1, 2, 5, 7, or 9. The group x positions interaction was also significant, F (27, 288) = 1.97, $p < .05$. Newman-Keuls comparisons indicated that at positions 4, 6, and 10, the imagery group performed with significantly less accuracy than either of the other three groups. The mean strategies x positions interaction scores for CE during the retention interval is displayed in Table 6.

Finally, the strategies x interval x positions interaction was significant, F (27, 288) = 1.58, $p < .05$.

Variable Error

A 4 x 2 x 10 (strategies x tests x positions) factorial ANOVA, with repeated measures on the last two factors, yielded a significant main effect for positions, F (9, 324) = 2.19, $p < .01$ and a significant tests x positions

Table 6

Mean Scores for Group X Interval X Position Interaction

for CE During Retention Interval

Position	1	2	3	4	5	6	7	8	9	10
Imagery										
Filled	3.200	-2.200	.300	-1.400	-7.100	-4.700	-2.900	1.300	3.900	-8.000
Unfilled	.200	-3.700	5.200	-12.100	5.300	-7.900	7.800	-2.800	3.400	-9.300
Chunking										
Filled	-2.900	-2.500	-2.300	-3.300	1.200	-1.600	.200	.300	-2.300	-4.600
Unfilled	-.300	.500	-1.200	1.400	-.300	-1.300	-1.000	1.900	-1.700	-1.900
Rhythm										
Filled	.100	.600	-.100	-3.700	.200	-2.500	-1.600	3.900	-1.900	-3.300
Unfilled	-2.300	5.500	5.400	-.600	.400	.100	-4.100	5.100	-1.400	-3.300
Control										
Filled	-1.200	-1.000	.900	-2.400	-4.200	-1.800	-5.500	4.100	-3.100	1.100
Unfilled	-.100	-2.200	-.700	-.700	-.100	.100	-1.000	1.700	-.600	-3.700

interaction $\underline{F}$ (9, 324) = 1.89, $\underline{p} < .05$. The mean scores for both effects are shown in Table 7.

The positions main effect indicated that, regardless of strategy group, subjects were more variable in their performance at position 10 than at positions 1, 3, 8, or 9.

The tests x positions interaction, illustrated in Figure 9, indicated that during the transfer phase, subjects displayed less response consistency at positions 2, 4, 6, 7, 9, and 10.

DISCUSSION

The increased accuracy displayed by all subjects during the transfer phase of the experiment appears to be reflective of familiarization with both the strategy usage as well as the task itself. Similar findings (Singer, Gerson, & Ridsdale, Note 5; Singer, Ridsdale, & Korienek, Note 6, Note 7) in investigations of strategy effectiveness would appear to lend additional support to this notion.

It is interesting to note that the typical primacy-recency effect generally exhibited during serial recall was not demonstrated by the significant positional effect. While primacy positions (1, 2, and 3) were reproduced rather accurately, recency positions (8, 9, and 10) were

Table 7

Mean Scores for Significant Effects for VE

Position	1	2	3	4	5	6	7	8	9	10
	2.925	3.450	3.050	3.600	3.500	4.113	3.875	3.150	2.538	4.988

Position / Test	1	2	3	4	5	6	7	8	9	10
Acquis.	2.575	1.750	2.900	1.950	3.050	3.150	2.875	3.150	1.900	3.600
Transfer	3.275	5.150	3.200	5.250	3.950	5.075	4.875	3.150	3.175	6.375

not. A possible explanation for this effect may be found in the strategy x position interaction illustrated in Figure 2. Although both the imagery and chunking groups were clearly more accurate at positions 8, 9, and 10, the extremely high error rate exhibited by the control group and rhythm group tended to elevate the mean absolute score. It would appear that while all strategies are equally effective in enhancing the reproduction of primacy locations, imagery and chunking provide a more accurate and consistent performance across all 10 positions. Such evidence would appear to lend credence to the possibility that while particular strategies may contribute in helping subjects to reproduce part of a task, others may be effective with other parts, and still others may be more generally effective with the entire task.

Also reflective of the serial position effect is the poorer performance exhibited at middle positions. However, in the present study, subjects did not display the usual decrement in middle position performance. In fact, at position 5, all three strategy groups displayed similar accuracy. It may well be that these particular strategies were more effective in aiding subjects to reproduce middle positions. Or, considering the number of positions to be remembered (10), an information overload may have resulted in a deviation from the serial position curve.

The overall lower error scores exhibited by all groups in comparison to a previous positioning investigation (Singer, Gerson, & Ridsdale, 1979) would appear to emphasize the importance of adequate strategy instruction before initial performance is measured. More specifically, in the present investigation experimental procedures involved an extensive explanation and demonstration of each strategy as it applied to the task. Additionally, subjects were required to demonstrate their knowledge of the strategy by incorporating the particular strategy as they performed practice trials with 10 positions.

Although strategy group performance reflects the unequivocal contention that strategy utilization can effectively improve performance, the effective performance exhibited by the control group is less easily explained. However, through questionnaire data collected after both acquisition and transfer phases, it was discovered that a number of control subjects utilized visual cues to aid their recall of positions. More specifically, subjects reported using shaded areas at either ends of the screen as well as the dots appearing after the "Go" signal in the reproduction phase as cues to particular position location. While it would appear to be impossible to remove all potential visual cues, emphasis should be placed upon minimizing extraneous variables which may possibly mediate and confound strategy group differences.

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APPENDIX A: INSTRUCTIONS TO SUBJECTS

Instructions for Serial Positioning Apparatus

Good morning. You are about to participate in a computer operated experiment. The task in this experiment will be to move a small white square that you will be able to see on the video monitor in front of you across the screen, using what we call a joystick. The joystick you'll find on a blue and white box, sitting right in front of you. Please grasp the joystick with your preferred hand, and notice that as you move the joystick to the left, the white square that you see on the video monitor also moves to the left. If you move the joystick to the right, the right square moves to the right. Regardless of how far you move the joystick, in either direction, the speed of the white square will remain constant. Do you see the white square?

You notice that on the blue and white box that contains the joystick, there are also four buttons. On top of the buttons they are labeled 1, 2, 3, and 4. This experiment is divided into two phases. One is called the demonstration phase, and the other is called the reproduction phase. During the demonstration phase, the computer shows you where it would like you to put the white square. During the reproduction phase, the computer asks you to reproduce the positions that it demonstrated for you. When you are reproducing the positions, you will do it by moving the joystick either to the left or to the right, positioning the white square on the screen where you think it should be, and where you have it where you think it should be., then you will press the #4 pushbutton on the left of the joystick box. You'll notice that on the video monitor right now, the computer is giving you several messages. It's telling you that this is a demonstration of the positions that you will have to reproduce. In the lower left hand corner of the screen, it's telling you that the next stop is to the left. You should hold the joystick with your preferred hand, push the joystick to the left, and the white square will move to the left. It will stop the white square when you get it into proper position, and it will print the number 1 directly above the white square.

There are several pieces of equipment in the testing room that you should know about. In front of your right shoulder you will see a microphone. This microphone will keep you in communication with me during the rest of the experiment. High on the wall in front of you, you'll see a speaker. If you have any questions, just speak into the microphone. I'll hear them and I'll answer you, and you'll hear my voice coming from that speaker. Do you understand the messages that you see on the video monitor? Do you understand the joystick operation, and the necessity of pushing the number 4 key? It's necessary to push the number 4 key after each position that you find. This is because as you move the white square to the position you think it is, as I'm doing right now, in order for the computer to know that you have moved the white square to the position you'd like it to be in, you have to press the number 4 key. Pressing the number 4 key tells the computer you have put the white square in the position you want it to be in. So, if you go to position 1, as I'm doing, press the number 4 key again, go to position 3, press the number 4 key again, and when you've done that, the computer will present on the monitor what we call feedback.

Feedback is what we're looking at right now. You'll notice that the first line is labeled position numbers 1 through 10. The second line is labeled distance error, and the third line, total distance error. The distance error you'll notice has plus and minus signs in front of it. Think of the correct position as equal to 0. If you have moved the white square too far to the left, your error will read "-"; if you have moved the white square too far to the right of the correct position, your error score will read "+". The distance error is measured in white square widths. So, if on your feedback the computer tells you that you missed your first stop position by minus 3, that means that you were 3 white square widths to the left of the stop position that you were trying to reproduce. Do you understand that? The line that reads total error is the sum of all the errors that you produce during that trial. When you are looking at your feedback, you should utilize this feedback to make an attempt to be more accurate the next time you try to reproduce those stop positions.

Do you have any questions? Do you feel that you can operate the equipment? If there are no questions and you feel comfortable with what we're about to do, we will start the experiment.

Imagery Strategy

I am going to explain a method or technique that I would like you to use on each trial throughout this experiment. This technique is called imagery.

Imagery is a method of forming a mental picture or image of something you have just seen. Think of imagery as taking a picture and being able to close your eyes and envision that picture.

For example, if you were standing in front of your house and were asked to close your eyes and describe as many features as possible, you would want to image or picture as many of the details as possible. This would mean picturing such things as the relationship and location of windows, doors, and shrubbery. If, however, you were simply asked to describe the outstanding features of your house, your image would only contain the most relevant features.

You will be asked to use the imagery technique throughout all trials in this experiment. As you have seen, the task requires you to be able to remember and reproduce positions in the correct order. However, now you will be given 10 positions to remember and reproduce. In order to remember the positions I would like you to use the imagery technique I have just explained. I will demonstrate how to use this method for you. Before I do,

do you have any questions?

As you can see on the screen, the cursor will identify the location and direction of all 10 positions. As the cursor moves to a position, I am going to image that point in my mind. With each new position, my image will begin to grow larger as I include more and more positions in the picture. Following the completion of all 10 positions, I will see on the screen information as to the sequential order of each stopping point. I will then try to create an image of all of these points and their relationship to one another. I will continue to hold the image in my mind until it is time to reproduce all 10 positions.

Watch as I demonstrate one trial. (Experimenter goes through demonstration trial of 10 positions, verbalizing aloud the image he/she is forming.) Now, using the total image I have formed, I will reproduce the 10 positions in the correct order. (Experimenter demonstrates, again verbalizing aloud. At the termination of the practice trial feedback will appear on the screen. At this time the experimenter will explain how to use the feedback information.)

As you were previously told, the information you see on the screen tells you how close you were to each of the 10 positions. Your goal in this task is to reproduce all 10 positions in the correct order. Therefore, you should try to reduce the error number you see for each position. The best way to accomplish this is to identify the positions where you have made the largest errors and try to correct them first. Whether your error is a "+" or a "-", you will have to adjust your image so that on the next trial you come closer to the correct position. Do you understand?

You will now be given the same 2 trials I have just demonstrated. During the first trial the direction of the cursor will appear on the screen, and the cursor will move to each position in order. During the second trial, the cursor will not appear. Therefore, you must reproduce the 10 positions, in the correct order, from memory. When you move the joystick to the position you think is correct, remember to press the #4 button on the side of the box. Do you have any questions?

As you complete each movement to a new position, close your eyes and describe to me the picture you see. Try to include the direction the cursor moved, as well as the relationship of one position to another. This is to let me know that you are using the imagery technique. During the acquisition trials you need not verbalize aloud.

(Subject goes through one demonstration and one practice trial of the same 10 positions demonstrated by the experimenter.)

You will now be given 10 new positions in which this same procedure will be followed. You will have only 1 practice trial where the cursor will identify the direction and location of each position. Therefore, it is important that you take as much time as you need during the practice trial. After each new position, close your eyes and add this position to your picture. The practice trials will be followed by 8 learning trials in which you must reproduce the positions, from memory, in the correct order. After each trial, the error information will appear on the screen.

Use the imagery technique during each trial. Use the error information to make corrections. In between trials, try to repeat your imagery, along with error information in order to improve your performance on the next trial.

Rhythm Strategy

I am going to explain a method or technique that I would like you to use on each trial throughout this experiment. This technique is called rhythm.

When you think of rhythm, you may think of a certain beat or tempo to music. In this sense, there can be fast rhythms and slow rhythms depending upon the speed of the music. It is possible to use rhythm during a series of movements. When you dance, you are moving your entire body in rhythm to the tempo of the music. In fact, whenever you repeat the same series of movements, at a specific pace, you are performing in a rhythmical fashion.

For example, if you were asked to move rhythmically from one point on the floor to another point, you might count to yourself: "one--and--two--and--three--and--four" as you move. When you arrived at the second point, you would pay close attention to the number you were saying at that time. Then, if you were asked to move the exact distance in a different direction, you would merely use the same rhythmical counting technique to travel the same distance.

You can now see how the rhythm technique allows you to repeat the same movement with consistency each time.

You will be asked to use the rhythm technique throughout all trials in this experiment. As you have just seen, the task requires you to remember and reproduce a number of different positions in the correct order. However, now you will be given 10 positions to remember and reproduce. In order to remember the positions, I would like you to use the rhythm technique I have just explained.

I will demonstrate how to use this method for you. Before I start, do you have any questions?

As you can see on the screen, during practice trials the cursor will identify the location and direction of all 10 positions. After each position has been identified, the cursor will return to the center of the screen. As soon as the white square begins to move, I am going to count in rhythm ("one--and--two--and," etc.) aloud until the square stops at a new position. At this time, I will repeat whatever number I have reached along with the direction I just moved. For example, if the square moves to the right and I count "one--and--two--and--three--and--four--and--five," and the square stops, I would attach "right" to "five" in order to remember that position. Since the square always returns to the center, I will always begin counting at number 1. Remember, the white square will always move at the same speed. Therefore, it is extremely important that I count with the same speed each time. It may be helpful to tap your foot as you count in order to keep the same tempo as you move to each new position.

Watch as I demonstrate one practice trial. (Experimenter goes through demonstration trial of 10 positions, verbalizing aloud each position and direction.)

Now, using the counting method for each position as well as the directional label, I will reproduce the 10 locations in the correct order without the cursor. (Experimenter verbalizes aloud the counting method. At the termination of the demonstration-practice trial, feedback will appear on the screen. At this time the experimenter will explain how to use the feedback information.)

As you were previously told, the information you see on the screen tells you how close you were to each of the 10 positions. Your goal in this task is to reproduce all 10 positions in the correct order. Therefore, you should reduce the error number you see for each position. The best way to accomplish this is to identify the positions where you have made the largest errors and try to correct them first. Whether your error is a "+" or a "-", you will have to adjust your counting. If your error is "+", you should stop counting earlier; if your error is "-", you should continue counting to the next number. In this way, you can come closer to the correct position on the next trial. Do you understand?

You will now be given the same 2 trials I have just demonstrated. During the first trial (demonstration), the direction of the cursor will appear on the screen and the cursor will move to each position in order. During the second trial (practice) the cursor will not appear. Therefore, you must reproduce the 10 positions, in the correct order, from memory. When you move the joystick to the position you think is correct, remember to press the #4 button on the side of the box. The white square will continually move at a constant spped. Therefore, try to be consistent as you count, maintaining the same speed of counting. Do you have any questions?

As you move to each position, verbalize aloud your rhythmic number along with the directional label. This is to let me know that you are using the rhythmic technique. During the acquisition trials, you need not verbalize aloud.

(Subject goes through one demonstration and one practice trial of the same 10 positions demonstrated by the experimenter.)

You will now be given 10 new positions in which the same procedure will be followed. You will have 1 practice trial where the cursor will identify the direction and location of each position. The practice trial will be followed by 8 learning trials in which you must reproduce the positions, from memory, in the correct order. Therefore, it is important that you take as much time as you need during the practice trial. After each trial, the error information will appear on the screen.

Use the rhythmic technique during each trial. Use the error information to make corrections. In between trials, try to repeat your rhythmic numbers along with error information in order to improve your performance on the next trial.

Chunking Strategy

I am going to explain a method or technique that I would like you to use on each trial throughout this experiment. This technique is called chunking.

Chunking is a method of combining several items into one or two groups (or chunks). For example, you may be asked to remember the telephone number 864-2379. Rather than trying to remember 7 individual numbers, it would be easier to remember numbers by combining 2 or more numbers together. Thus, 864 might be the first chunk, 23 the second chunk, and 79 the third chunk. In this way, you are reducing the number of items to be remembered from 7 items to 3 items.

You will be asked to use this chunking technique throughout all trials in this experiment. As you have just seen, the task requires you to be able to remember and reproduce a number of different positions in the correct order. However, now you will be given 10 positions to remember and reproduce. In order to remember the positions, I would like you to use the chunking method I have just explained. I will demonstrate how to use this method for you. Before I start, do you have any questions?

As you can see on the screen, the cursor will automatically show you the location and direction of each of the 10 positions. You will also notice that after each position is identified, the white square returns to the center of the screen. Therefore, every position will be either to the left or the right of the center point. This allows me to divide the screen into a left chunk and a right chunk. As the positions are shown to me, I am going to chunk them as to their location on the screen; either in the right chunk or the left chunk. In addition, I will also have to be aware of the distance between positions in each of my chunks. As I include a new position, my chunks will become larger. Watch as I demonstrate. (Experimenter demonstrates first 3 positions, then stops.) As you can see, I have 2 positions to the right of center and 1 position to the left of center. Therefore, my left chunk is ___ and my right chunk is ___. (Experimenter continues moving joystick to next 3 positions.) Now, tell me what numbers comprise my left chunk; my right chunk. As you can see, each new position is added to my existant chunk.

Now, using these chunks, I will reproduce the 10 positions, in the correct order, without the white square. Once I move the joystick to the position I think is correct, I push the #4 button. (Experimenter demonstrates, verbalizing how she/he remembers the positions by relating them to the right or left chunk). At the termination of the demo-practice trial, feedback will appear on the screen. At this time, the experimenter will explain how to use the information.

As you were told previously, the information you see on the screen tells you how close you were to each of the 10 positions. Your goal in this task is to reproduce all 10 positions in the correct order. Therefore, you should reduce the error number you see for each position. The best way to accomplish this is to identify the positions where you have made the largest errors and try to correct them first. Whether your error is a "+" or a "-", you will have to adjust the locations of positions within your chunk so that on the next trial, you come closer to the correct position. Do you understand?

You will now be given the same 2 trials I have just demonstrated. During the first trial, the direction of the cursor will appear on the screen, and the cursor will move to each position in order. During the second trial, the cursor will not appear. Therefore, you must reproduce the 10 locations, in the correct order, from memory. When you move the joystick to the position you think is correct, remember to press the #4 button on the left side of the box. Do you have any questions?

As you complete each location, verbalize the area of the screen that represents that chunk and also repeat both left and right chunks. This is to let me know that you are using the chunking technique. During the acquisition trials, you need not verbalize aloud. (Subject goes through 1 demonstration and 1 practice trial of same 10 positions demonstrated by experimenter.)

You will now be given 10 new positions in which this same procedure will be followed. You will have 1 practice trial where the cursor will identify the direction and location of each position. The practice trial will be followed by 8 learning trials in which you must reproduce the position, from memory, in the correct. Therefore, it is important that you take as much time as you need during the practice trial. After each trial, the error information will appear on the screen.

Use the chunking technique during each trial. Use the error information to make corrections. In between trials, try to repeat your chunks, along with error information in order to improve your performance on the next trial.

Control Instructions

You have just seen me demonstrate the task with 5 positions. However, you will be required to remember and reproduce 10 positions. In order to acquaint you with the real task, I will now go through one demonstration and one practice trial with 10 positions. After my demonstration you will be given an opportunity to practice the same 10 positions. Try to take advantage of this time to learn the task well.

Do you have any questions?

Transfer Directions

You have just been tested on phase I of the experiment. You will now undertake a second task which will require you to learn *10 new positions*. You will receive 1 demonstration and 2 practice trials that will be administered in the same manner as the previous task. However, after each position is identified for you, the cursor will automatically return to the center of the screen.

Remember, you may take as much time as you need during the practice trials, in order to remember the position sequence.

Do you have any questions?

Questionnaire

1. Did you use the strategy you were taught? Yes__No__
   (Do not ask this question of subjects in the control group.)

2. What strategy did you use?
   (a) imagery
   (b) chunking
   (c) coding
   (d) rhythm
   (e) counting
   (f) self verbalization
   (g) other

3. Rate the difficulty you encountered in using your strategy on a 1 to 5 scale with 1 being the easiest and 5 being the most difficult.

   1 2 3 4 5

4. Do you feel that using the strategy improved your performance on this task? Yes__No__

5. Did you change strategies at any time during the experiment? Yes__No__

6. Do you think you will use this strategy during your everyday activities? Yes__No__

7. Would you rate your feelings about this experiment on a scale of 1 to 5 with 1 meaning you found it to be a learning experience for you and 5 meaning it was a waste of time?

   1 2 3 4 5

8. Did you have any problems with the apparatus? Yes__No__

9. Are you satisfied with your performance in this experiment? Yes__No__

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